PATENT **A-68779/RBC/VEJ**

presented below for the Examiner's convenience:

--~~20~~ 1. (Thrice Amended) An electroplating device for wafer metallization [as set forth in claim 39, which further comprises] of a wafer for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold the wafer above said reservoir,

a counter-electrode in said reservoir,

means adapted for passing current between said counter-electrode and the wafer in said holder,

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a pump adapted for pumping electrolyte from said reservoir against the wafer in said holder, and

a non-conducting porous separator between said wafer holder and said counter-electrode.--

--~~23~~ 2. (Thrice Amended) An electroplating device for wafer metallization [as set forth in claim 39,] of a wafer for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold the wafer above said reservoir,

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a counter-electrode in said reservoir, said counter-electrode disposed concentrically with said holder,

means adapted for passing current between said counter-electrode and the wafer in said holder,

a pump adapted for pumping electrolyte from said reservoir against the wafer in said holder, and

wherein the diameter of said counter- electrode is smaller than the diameter of said wafer holder.--

3 --~~25~~. (Thrice Amended) An electroplating device [according to claim 41] for wafer metallization of a wafer for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold the wafer above said reservoir,

a counter-electrode in said reservoir,

means adapted for passing current between said counter-electrode and the wafer in said holder,

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a pump adapted for pumping electrolyte from said reservoir against the wafer in said holder, and

a [in which said] distributor positioned in said reservoir and [is] formed with holes at an angle to the flow direction of the electrolyte whereby electrolyte causes rotation of said distributor and emerges from said distributor in the form of multiple submerged jets adapted to contact a face of said wafer held in such holder.--

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--~~26~~. (Thrice Amended) An electroplating device for wafer metallization as set forth in claim 14 ~~39~~ which further comprises a distributor in said reservoir positioned in front of said holder, said distributor being formed with holes at an angle to the flow direction of the electrolyte, said distributor being below the level of the electrolyte [and above said distributor], and means for forcing electrolyte through said distributor in the form of multiple jets contacting the surface of said wafer in said holder and causing rotation of said distributor, said jets serving as an ionic path for the passage of current between said wafer and said counter-electrode.--

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--~~27~~. (Thrice Amended) An electroplating device for wafer metallization [as set forth in claim 39 which further comprises] of a wafer for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold the wafer above said reservoir,

a counter-electrode in said reservoir,

means adapted for passing current between said counter-electrode and the wafer in said

holder.

a pump adapted for pumping electrolyte from said reservoir against the wafer in said holder, and

means for periodically reversing current adapted to remove excess electroplating metal from areas on the wafer in said holder where the electroplating is thicker than the average and wherein the total electrical charge passed during the reversed current period is smaller than the total charge passed during the forward current period.--

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--~~28~~ 5. (Thrice Amended) An electroplating device for wafer metallization [as set forth in claim 39 which further comprises] of a wafer for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold the wafer above said reservoir,

a counter-electrode in said reservoir,

means adapted for passing current between said counter-electrode and the wafer in said holder,

a pump adapted for pumping electrolyte from said reservoir against the wafer in said holder, and

means for applying pulsed current to said pump during the electroplating process.--

29. (Unchanged) An electroplating device for wafer metallization as set forth in claim 39 wherein said holder is stationary and which further comprises means for rotating said reservoir.

30. (Unchanged) An electroplating device for wafer metallization as set forth in claim 39 which further comprises means for rotating said wafer holder.

--~~31~~ 6. (Thrice Amended) An electroplating device for the metallization of wafers for interconnection comprising an electroplating apparatus having a reservoir adapted to contain

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electrolyte, a holder for a wafer coated with a thin barrier layer and a thin seed layer of the metal to be electroplated, an assembly of contact pegs on an insulating ring masking the circumferential edge of said wafer and pressing against said wafer, insulating sleeves insulating said pegs from electrolyte in said reservoir except at the points of contact with the wafer, said contact pegs being spatially distributed over the surface of said wafer to ensure uniform electroplating of the metal over the entire wafer, and means for feeding electrical current from a contact to the center of the wafer and from a plurality of contact points at said counter-electrode.--

32. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises means for rotating said contact pegs assembly and said wafer together.

33. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises a pump to pulse electrolyte upward against a wafer held in said holder while said wafer is resting on said contact pegs and said insulating ring.

34. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises means for rotating said contact peg assembly and said wafer while said electrolyte is pumped upward against said rotating wafer, said holder supporting said wafer so that an active surface of a wafer is exposed to electrolyte and the opposite side of said wafer is protected from said electrolyte.

35. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises means for periodically reversing the current to remove excess electroplating metal from areas on the wafer where the electroplating is thicker than the average and wherein the total electrical charge passed during the reversed current period is smaller than the total charge passed during the forward current period.

36. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises means to pulse said pump during the electroplating process.

37. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 wherein said wafer is stationary and which further comprises means for rotating said reservoir.

38. (Unchanged) An electroplating device for wafer metallization as set forth in claim 31 which further comprises means for rotating said wafer.

--~~39.~~ (Amended) An electroplating device for metallization of a wafer coated with a thin barrier layer and a thin seed layer of a metal to be electroplated over the barrier layer with an electrolyte containing an electroplated metal in solution for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold [a] the wafer above said reservoir,

a counter-electrode in said reservoir,

means adapted for passing current between said counter-electrode and [a] the wafer in said holder,

a pump adapted for pumping electrolyte from said reservoir against [said] the wafer in said holder,

means for adjusting the plating parameter ~~B2~~ of the electrolyte wherein:

~~B2 = (ρ/ρel) (R2/Wd) ≤ 1~~

where ρ and ~~ρel~~ are the resistivities of the metal to be electroplated and the electrolyte, respectively, R is the radius of the wafer, W is the thickness of the electroplated metal and d is the distance between said wafer and said counter-electrode.--

40. (Unchanged) An electroplating device according to claim 39 which further comprises means for causing relative rotation between said holder and said reservoir.

19 --41. (Amended) An electroplating device [according to claim 39 which further comprises] of wafers for interconnection comprising:

a reservoir for electrolyte,

a holder adapted to hold a wafer above said reservoir,

a counter-electrode in said reservoir,

means for passing current between said counter-electrode and a wafer in said holder,

a pump for pumping electrolyte from said reservoir against said wafer, and

a distributor positioned in said reservoir including a disk having a plurality of holes adapted to provide a flow of electrolyte through the disk that is uniform along a radius of the disk.--

42. (Unchanged) An electroplating device according to claim 41 which further comprises means for rotating said distributor relative to said holder.

21 --43. (Amended) A method of electroplating for the metallization of wafers for interconnection comprising:

providing a reservoir containing a counter-electrode,

providing a holder above said reservoir,

providing a wafer coated with a thin barrier layer and a thin seed layer of the metal to be electroplated over said barrier layer in said holder,

placing an electrolyte containing an electroplated metal in solution in said reservoir and adjusting the plating parameter B^2 of said electrolyte wherein:

$$B^2 = (\rho/\rho_{el})\,(R^2/Wd) \leq 1$$

where ρ and ρ_{el} are the resistivities of said metal to be electroplated and said electrolyte, respectively, R is the radius of said wafer, W is the thickness of the electroplated metal and d is the distance between said wafer and said counter-electrode,

a pump to pump said electrolyte upward against said wafer, and

passing a current between said counter-electrode and said wafer.--

44. (Unchanged) A method according to claim 43 which further comprises positioning a non-conducting porous separator in said electrolyte above said counter-electrode.

45. (Unchanged) A method according to claim 43 wherein the concentration of said electrolyte is such that $B^2 \leq 1$.

46. (Unchanged) A method according to claim 43 which further comprises placing leveling agents in solution with said electrolyte to increase charge transfer resistance at a metal/electrolyte interface.

47. (Unchanged) A method according to claim 43 wherein the size of said counter-electrode is smaller than the size of said wafer.

48. (Unchanged) A method according to claim 43 which further comprises rotating a distributor in said reservoir.

49. (Unchanged) A method according to claim 48 in which said distributor is formed with holes at an angle to flow direction whereby electrolyte merges from said distributor in the form of multiple jets submerged in electrolyte directed at a face of said wafer.

50. (Unchanged) A method according to claim 49 in which said jets cause rotation of said distributor.

51. (Unchanged) A method according to claim 49 wherein said jets perform said step of passing a current between said counter-electrode and said wafer.

52. (Unchanged) A method according to claim 43 in which said step of passing current comprises periodically reversing said current, the period of reversed current being

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smaller than the period of forward current.

53. (Unchanged) A method according to claim 43 in which said step of pumping said electrolyte comprises pulsing said pump.

54. (Unchanged) A method according to claim 43 which further comprises causing relative rotation between said wafer and said reservoir.

55. (Unchanged) A method according to claim 54 in which said reservoir is rotated.

56. (Unchanged) A method according to claim 54 in which said wafer is rotated. --

57. (Unchanged) A method according to Claim 43 wherein said step of adjusting the plating parameter comprises adjusting W.

58. (Unchanged) A method according to Claim 43 wherein the step of adjusting the plating parameter comprises adjusting d.

59. (Unchanged) A method according to Claims 43 wherein said step of passing a current comprises pulsing said current.

REMARKS

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